Text box

Dan Green

US CMS Technical Director

Outline

- CMS and US CMS Description - System Overview
- The L2 Subsystems
- CMS Organization
- US CMS L2 Organization
- Institutional L2 Affiliations
- US CMS Schedule at L1, Milestones
- Status and Progress to Date
- US CMS WBS Summary
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- WBS Cost Drivers, M&S, Labor, EDIA, and Contingency
- WBS Dictionary and Basis of Estimate
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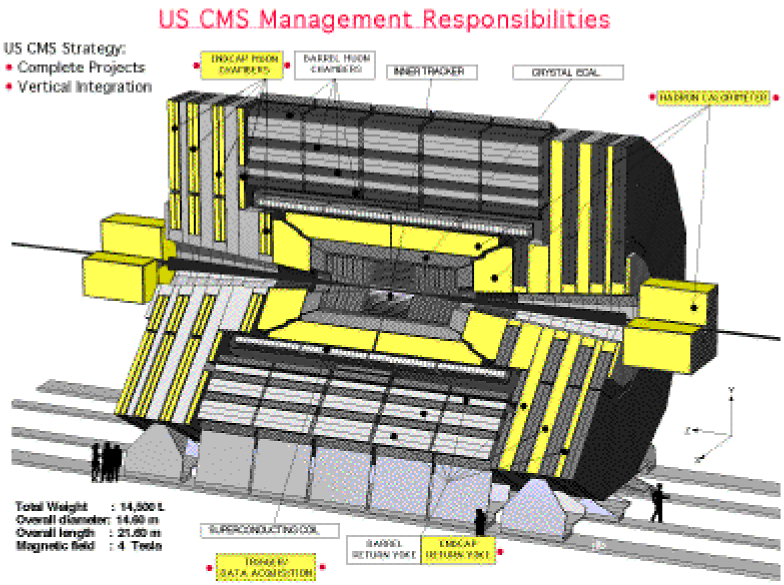
- Obligation Yearly Profile, L2 Subsystems
- The US CMS Resource Pool
- Annual US CMS Manpower Usage
- Concerns and How They Are Being Addressed
- Summary and Conclusion

US CMS Responsibilities

Management:

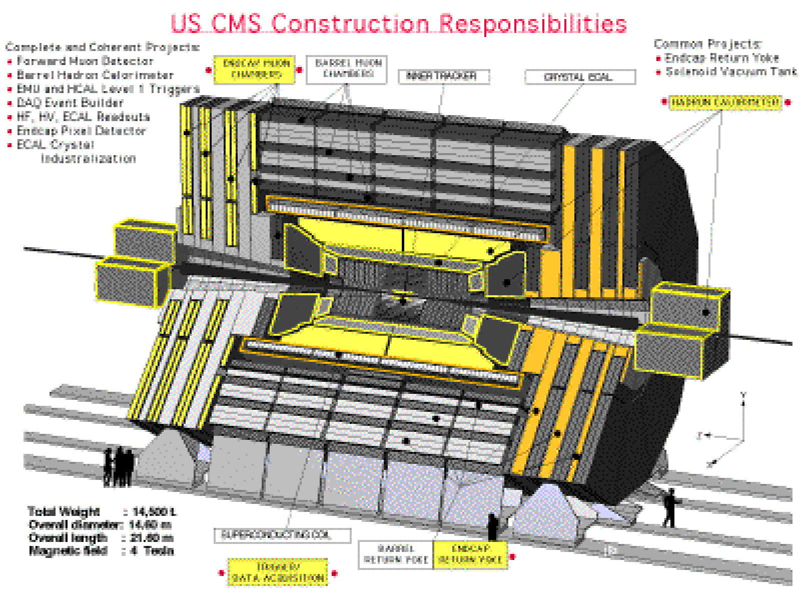


WBS 1. Endcap Muon Management

WBS 2. HCAL Management

WBS 3. Trigger Management

Construction:



WBS 1. Endcap Muon Cathode Strip Chambers

WBS 2. HCAL Barrel, plus Endcap and Forward Transducers and Readout

WBS 3. First Level Muon and HCAL Trigger. Event Builder Switch.

WBS 4. ECAL Barrel Transducers and Front End Electronics

WBS 5. Tracking Forward Pixels

WBS 6. Common Projects - Endcap Yoke and Barrel Yoke/Vacuum Tank

WBS 7. Project Management

CMS Subdetectors

- **The tracking system measures trajectories in a magnetic field, thus determining position and momentum of the produced particles. There are 3 components of tracking; silicon pixels, silicon strips, and microstrip gas chambers (MSGC).**

- **The electromagnetic calorimeter (ECAL) measures the energy and position of the photons and electrons, which strike it. The ECAL system is made of transparent crystals of $PbWO_4$ read out by avalanche photodiodes (APD).**

- **The hadron calorimeter (HCAL) measures the energy and position of all strongly interacting particles, which impinge upon it. It is built of scintillator tiles and wavelength shifter (WLS) fibers read out by hybrid photodiodes (HPD) in the barrel and endcap (HB and HE) and quartz fibers read out by photomultipliers (PMT) in the forward region (HF).**

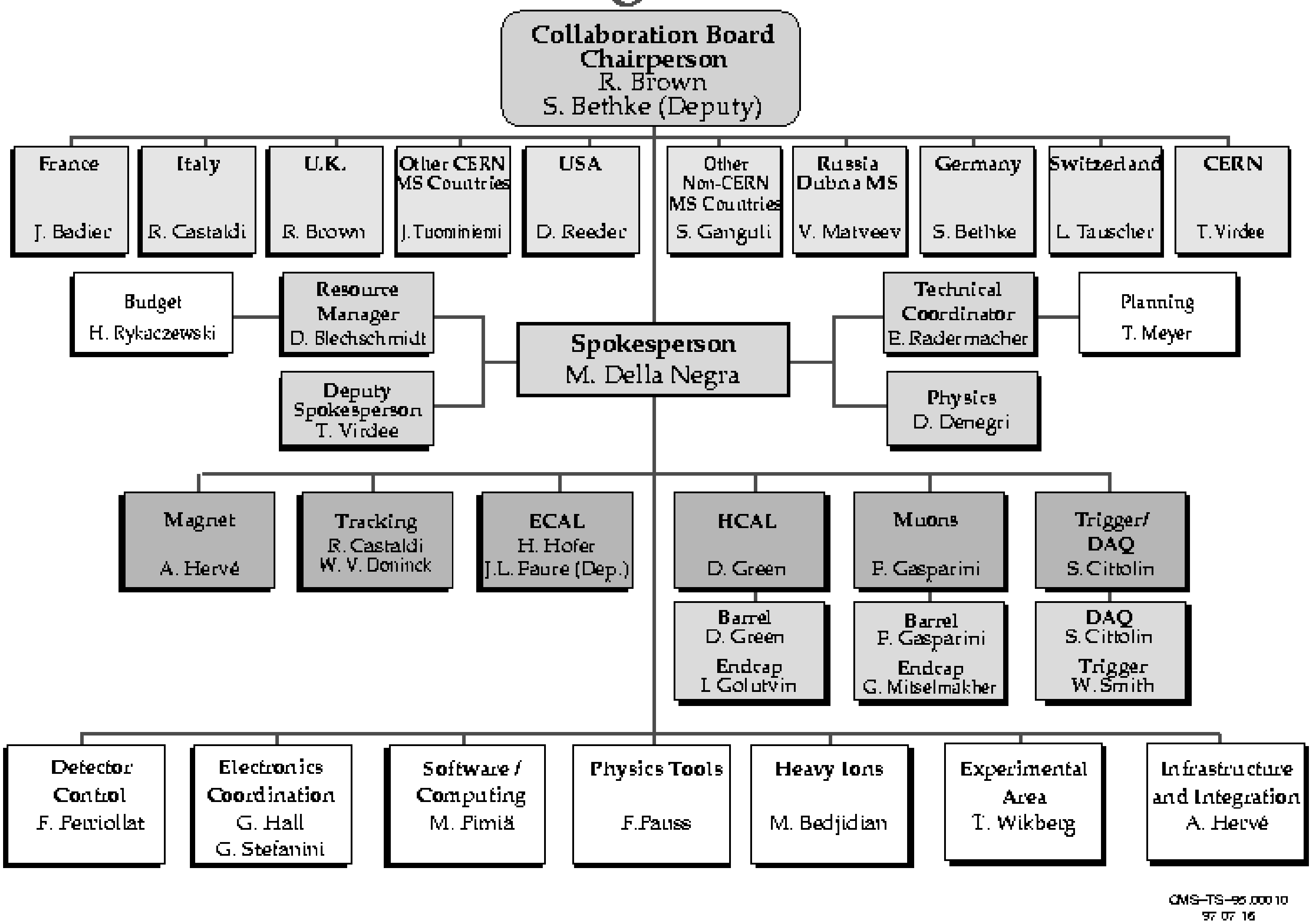
- **The magnet is a 4T electromagnet with a superconducting cryogenically cooled coil enclosed in a vacuum tank whose magnetic flux is returned by barrel and endcap steel (YB and YE).**

- **The muon system remeasures the momentum and position of the muons, which survive the passage through all the other CMS detectors. The detectors are drift tubes in the barrel (MB) and cathode strip chambers (CSC) in the endcap (ME). Resistive plate chambers (RPC) are also used as a second, redundant, trigger system.**

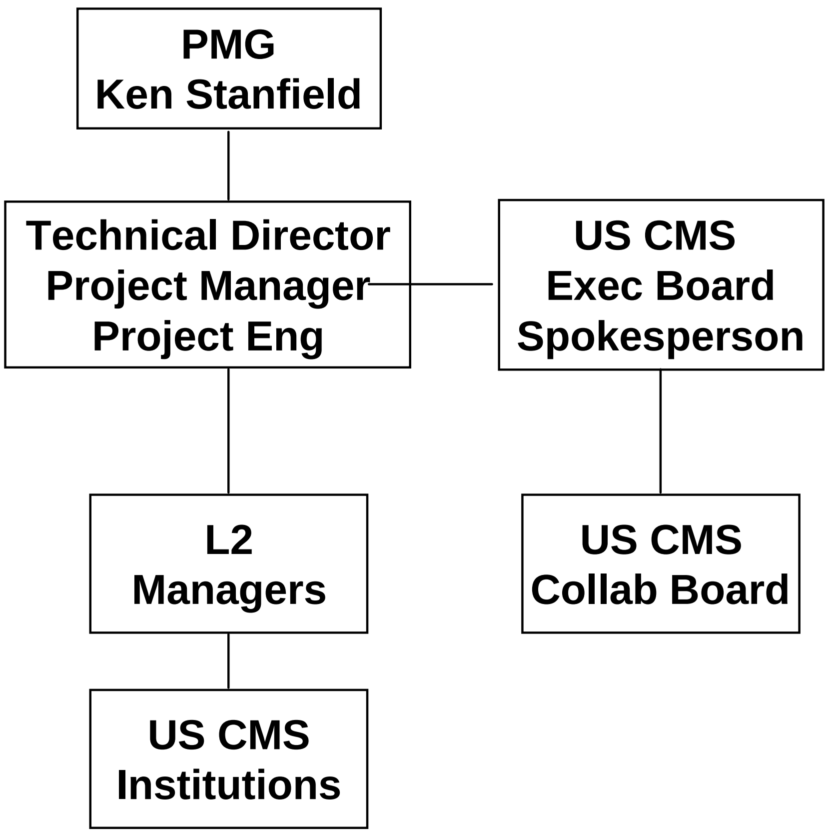
- **The CMS detector operates at 10^9 interactions/sec. The function of the trigger system is to first reduce the rate to 100 kHz of interesting events ((L1) and then to 100 Hz of events to be saved for later examination (L2). The function of the data acquisition system (DAQ) is to assemble the full event from the subsystem data and record it on some permanent medium.**

CMS Management

CMS Management Board

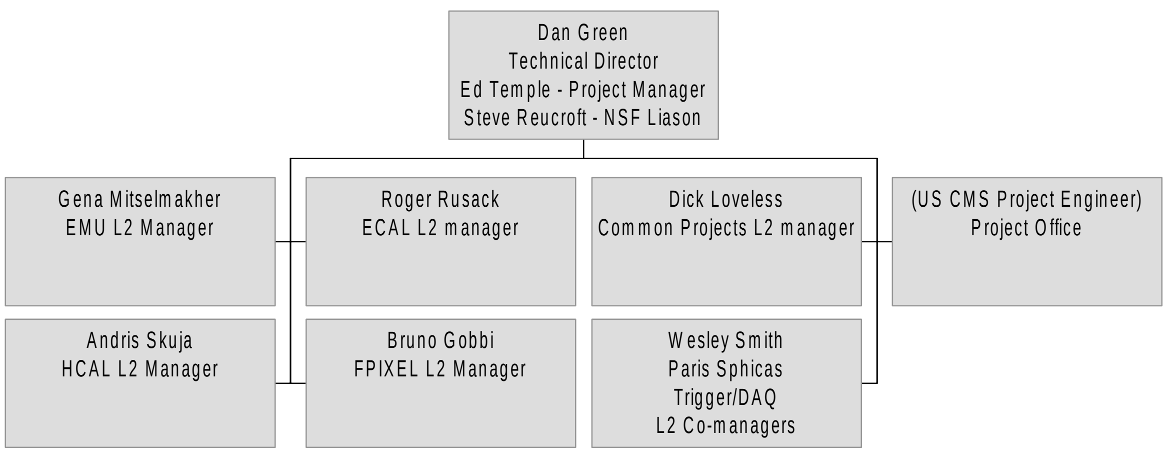


US CMS
Project Management
and Collaboration



US CMS L2 Managers

US CMS Project



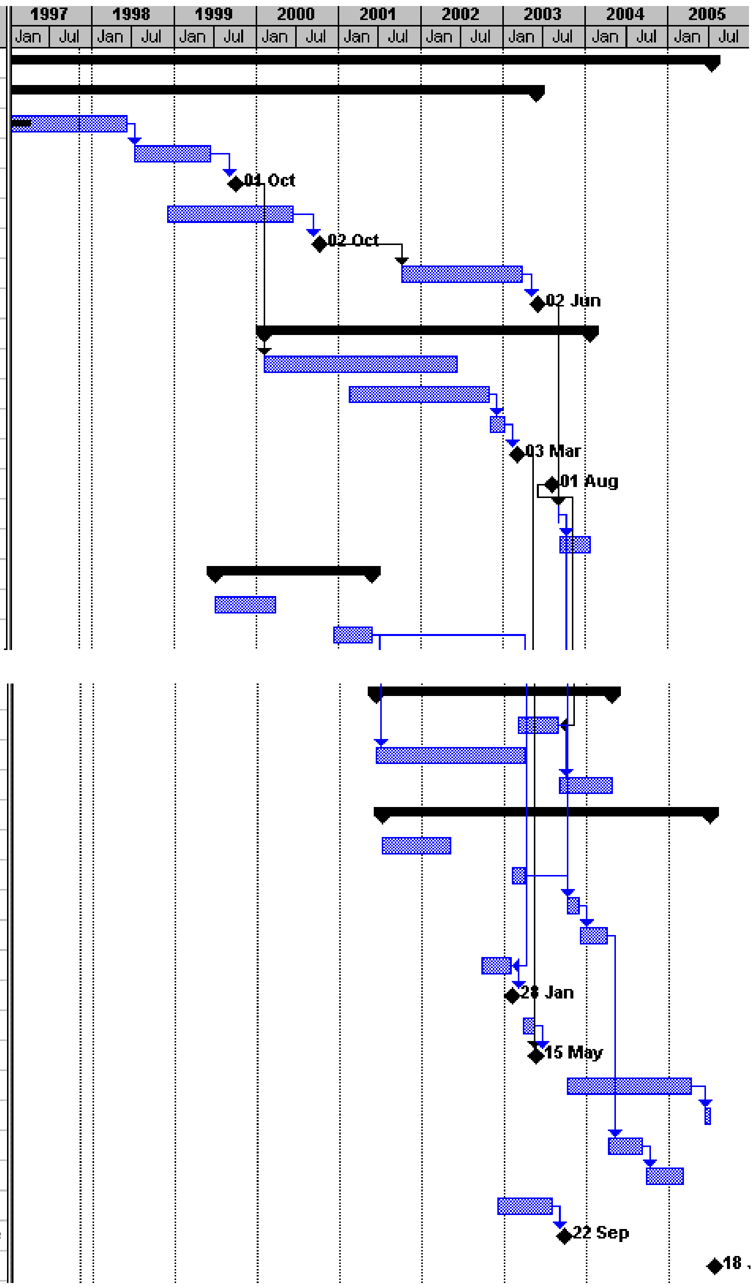
L2 Participation

Endcap Muon	Hadron Calorimeter	Trigger/DAQ
Alabama	Boston	UC Davis
UC Davis	UCLA	UCLA
UCLA	Fairfield	UC San Diego
UC Riverside	Fermilab	Fermilab
Carnegie Mellon	Florida State	Iowa
Fermilab	Illinois Chicago	Iowa State
Florida	Iowa	MIT
Livermore	Iowa State	Mississippi
SUNY Stony Brook	Maryland	Nebraska
Northeastern	Minnesota	Northeastern
Ohio State	Mississippi	Ohio State
Purdue	Notre Dame	Rice
Rice	Purdue	Wisconsin
UT Dallas	Rochester	
Wisconsin	Texas Tech	
	Virginia Tech	

Electromagnetic Calorimeter	Tracking	Software
Brookhaven	UC Davis	UC Davis
Caltech	Fermilab	UCLA
Fermilab	Florida State (SCRI)	UC Riverside
Livermore	Johns Hopkins	UC San Diego
Minnesota	Livermore	Caltech
Northeastern	Los Alamos	Carnegie Mellon
Princeton	Mississippi	Fermilab
	Northwestern	Florida
	Purdue	Florida State (SCRI)
	Rice	Johns Hopkins
	Texas Tech	Livermore
		Maryland
		Missesota
		SUNY Stony Brook
		Northeastern
		Princeton
		Purdue
		Rice
		Wisconsin

L1 US CMS Schedule

WBS	Task Name
1	**L1 - US CMS Project**
1.1	**Experimental Halls**
1.1.1	D=Design,AH=Assembly Hall
1.1.2	F=Fabricate AH
1.1.3	BO=Beneficial Occup AH
1.1.4	D CH=Collision Hall
1.1.5	LEP stop
1.1.6	F CH
1.1.7	BO CH
1.2	**Magnet**
1.2.1	Assemble coil in AH
1.2.2	Weld outer and inner tanks
1.2.3	Final Weld of Vactank
1.2.4	HB in Vac Tank-test
1.2.5	Mag power test in AH
1.2.6	I=Install magnet in CH
1.2.7	C=Commission magnet in CH
1.3	**Yoke-Endcap(YE)**
1.3.1	Assemble YE- yoke
1.3.2	Assemble YE+ yoke
1.4	**Muon**
1.4.1	Assemble CSC YE- in AH
1.4.2	Assemble CSC YE+ in AH
1.4.3	I ME in CH
1.5	**HCAL**
1.5.1	Assemble HB+ in AH
1.5.2	Assemble HB- in AH
1.5.3	Insert HB into Magnet in CH
1.5.4	Commission HB
1.5.5	Assemble HE+
1.5.6	HE+YE+ connect
1.5.7	Assemble HE-
1.5.8	HE-YE- connect
1.5.9	Assemble HF in AH
1.5.10	Install HF and shielding
1.6	**ECAL - install EB**
1.7	**Tracker - install**
1.8	**Install Counting Room**
1.9	**BO Underground Counting House**
1.10	**CMS - First Beam**



US CMS L1 Milestones

WBS	Task Name	Duration	Start
1	**L1 - US CMS Project**	**2253d**	**Wed 27-11-96**
1.1	**Experimental Halls**	**1698d**	**Wed 27-11-96**
1.1.3	BO=Beneficial Occup AH	0d	Fri 01-10-99
1.1.5	LEP stop	0d	Mon 02-10-00
1.1.7	BO CH	0d	Mon 02-06-03
1.2	**Magnet**	**1038d**	**Thu 03-02-00**
1.2.4	HB in Vac Tank-test	0d	Mon 03-03-03
1.2.5	Mag power test in AH	0d	Fri 01-08-03
1.5	**HCAL**	**1045d**	**Wed 04-07-01**
1.5.6	HE+YE+ connect	0d	Tue 28-01-03
1.5.8	HE-YE- connect	0d	Thu 15-05-03
1.9	**BO Underground Counting House**	**0d**	**Mon 22-09-03**
1.10	**CMS - First Beam**	0d	Mon 18-07-05
1.11	**US CMS Baseline**	0d	Mon 02-03-98
1.12	**US CMS MOU**	0d	Tue 14-04-98
1.13	**US CMS End of Project**	0d	Fri 01-10-04

Progress and Status

- **US CMS Constitution written. Project Office (PO) and Collaboration are distinct.**

- **US CMS Project Management Plan (PMP) is rewritten. PO has been strengthened. Technical Director and Construction Project Manager appointed.**

- **Project Engineers have been hired for the full Project and for the EMU and HCAL L2 subprojects.**

- **An integrated cost and schedule has been put in place based on MS PROJECT/EXCEL. Both M&S and Labor are treated uniformly and the WBS Dictionary and contingency treatment are included.**

- **Contingency, based on HEP experience, has been uniformly applied to all subsystems at the lowest WBS level. The Common Project contingency has been assessed.**

- **A yearly Statement of Work (SOW) has been put in place for FY98 which sets up tracking and reporting of obligations and costs at L7 of the WBS (1-10 k$) for each collaborating institution.**

- **A Memorandum Purchase Order (MPO) is the default option for the distribution of funds within the collaboration. Funds will be tracked in the FNAL financial plan with a small passthrough rate applied to US CMS Project funds. This method improves the PO control of contingency funds.**

Contingency Analysis

Contingency = (Design Maturity) * (Judgment)

Design Maturity

DM = 1.5: There is only a conceptual design.
DM = 1.4: There is a RFI or request for vendor information, with engineering sketches.
DM = 1.3: There is a TDR with an engineering design.
DM = 1.2: There is a bid package ready to go out, or a quote.
DM = 1.1: The bid is awarded, or a purchase order is written, or the item is from a catalogue.
DM = 1.0: The item is invoiced/completed.

Judgment

There are other factors which should be taken into account. The schedule risk if the item is on or influences the critical path items should be taken into account. The technical risk is crucial. Is the item new design (e.g. pixel readout) or a small modification (e.g. tile/fiber optics) or is it a standard design (e.g. the CSC gas system)? The range for judgment might typically go from 1.0 to 1.5 depending on the schedule and technical risk factors or on other considerations. This factor should be uniformly applied at L7.

Note that, other HEP experience is relevant in making an informed judgment as to the level of contingency. In quoting past experience, one should take the projects most similar to the present US CMS effort.

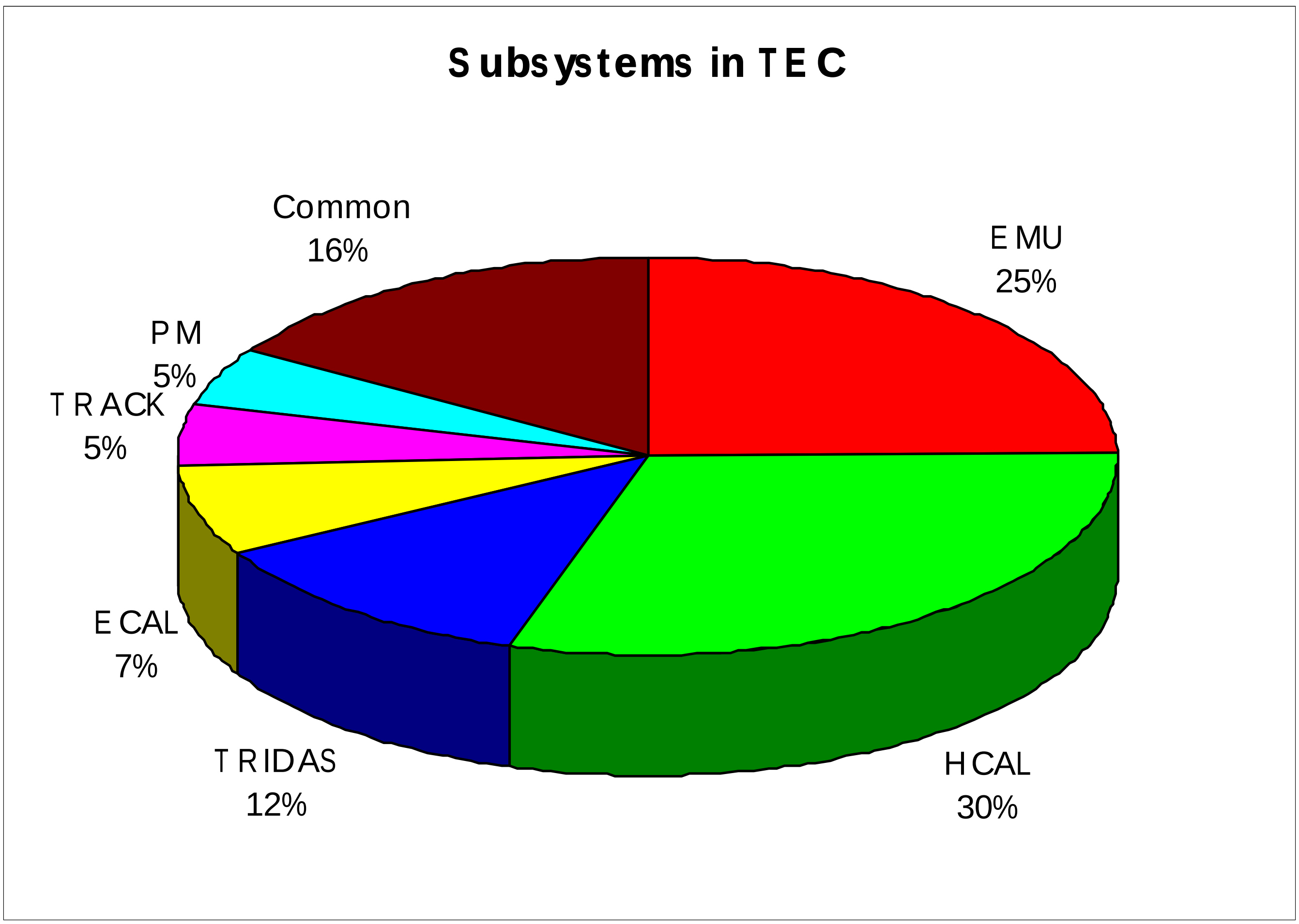
US CMS WBS Rollup

US CMS ProjectCost Estimate 31/5/97

WBS Number	Description	US Mfg M&S (K$)	US Mfg Labor (K$)	US EDIA (K$)	US Base Cost (K$)	US Cont (K$)	Cont (%)	Total US Cost (K$)	DOE Request (K$)	NSF Request (K$)
US CMS Total Project Cost (then-yr $s)								168,323	146,997	21,327
Escalation								18,788	16,566	2,222
FY97 R&D								4,920	4,620	300
FY96 R&D (FY97 $s)								2,563	2,358	205
US CMS Total Estimated Cost (FY97 $s)								142,052	123,453	18,600
Total Subsystem Estimated Cost		60,317	11,007	13,847	85,170	27,431	32	112,601	97,556	15,046
1	Endcap Muon System	18,698	4,465	3,844	27,007	8,172	30	35,179	33,730	1,449
1.1	CSC Chambers	8,639	3,001	1,790	13,430	4,205	31	17,634	17,634	
1.2	Electronics	8,241	937	1,357	10,535	3,183	30	13,718	13,718	
1.3	Mechanical Structure	375	59	46	480	120	25	600	600	
1.4	Assembly/Installation	176	170	80	426	101	24	527	527	
1.5	Monitoring	25		15	40	10	25	50	50	
1.6	Services	560	178	137	875	266	30	1,141	1,141	
1.7	Alignment	682	120	360	1,162	287	25	1,449		1,449
1.8	RPC Chambers			60	60			60	60	
2	Hadron Calorimeter	24,165	5,210	2,933	32,308	10,271	32	42,579	35,732	6,847
2.1	Barrel Hadron Calorimeter	18,404	4,010	2,502	24,916	7,931	32	32,847	28,236	4,612
2.2	Endcap Hadron Calorimeter	2,867	844	251	3,963	1,311	33	5,274	3,547	1,727
2.3	Forward Calorimeter	2,894	356	179	3,429	1,029	30	4,458	3,949	508
3	Trigger/Data Acquisition	9,234	0	3,801	13,035	4,439	34	17,474	15,952	1,522
3.1	Trigger	4,153		2,214	6,367	1,918	30	8,286	8,286	
3.2	Data Acquisition	5,080		1,587	6,667	2,521	38	9,188	7,667	1,522
4	Electromagnetic Calorimeter	4,992	816	1,966	7,774	2,345	30	10,119	7,635	2,485
4.1	Photodetectors	1,965	157	500	2,622	904	34	3,526	1,042	2,485
4.2	FrontEndElectronics	2,358	421	765	3,544	1,207	34	4,751	4,751	
4.3	Special Engineering	130	7	538	675	83	12	757	757	
4.4	Monitoring Light Source	523	231	163	917	152	17	1,069	1,069	
4.5	Crystal Development	16			16			16	16	
5	Forward Pixel Tracker	3,229	515	1,303	5,047	2,203	44	7,250	4,507	2,743
5.1	Readout system	1,426	35	610	2,071	978	47	3,049	1,722	1,328
5.2	Sensor arrays	577		268	845	372	44	1,217		1,217
5.3	Mechanical and cooling	372	251	271	894	406	45	1,300	1,302	
5.4	Slow controls and monitoring	100		10	110	42	38	152	28	125
5.5	Final assembly and testing	754	229	144	1,127	405	36	1,532	1,455	73
6	Common Projects	21,808	119	1,050	22,977	0	0	22,977	19,965	3,012
6.1	Endcap Iron Flux Return	18,116	119	1,050	19,285			19,285		
6.2	Vacuum Tank	3,692			3,692			3,692		
7	Project Management	0	0	4,991	4,991	1,483	30	6,474	5,932	542
7.1	Project Administration			2,798	2,798	826	30	3,624	3,082	542
7.2	Technical Coordination			2,193	2,193	657	30	2,850	2,850	

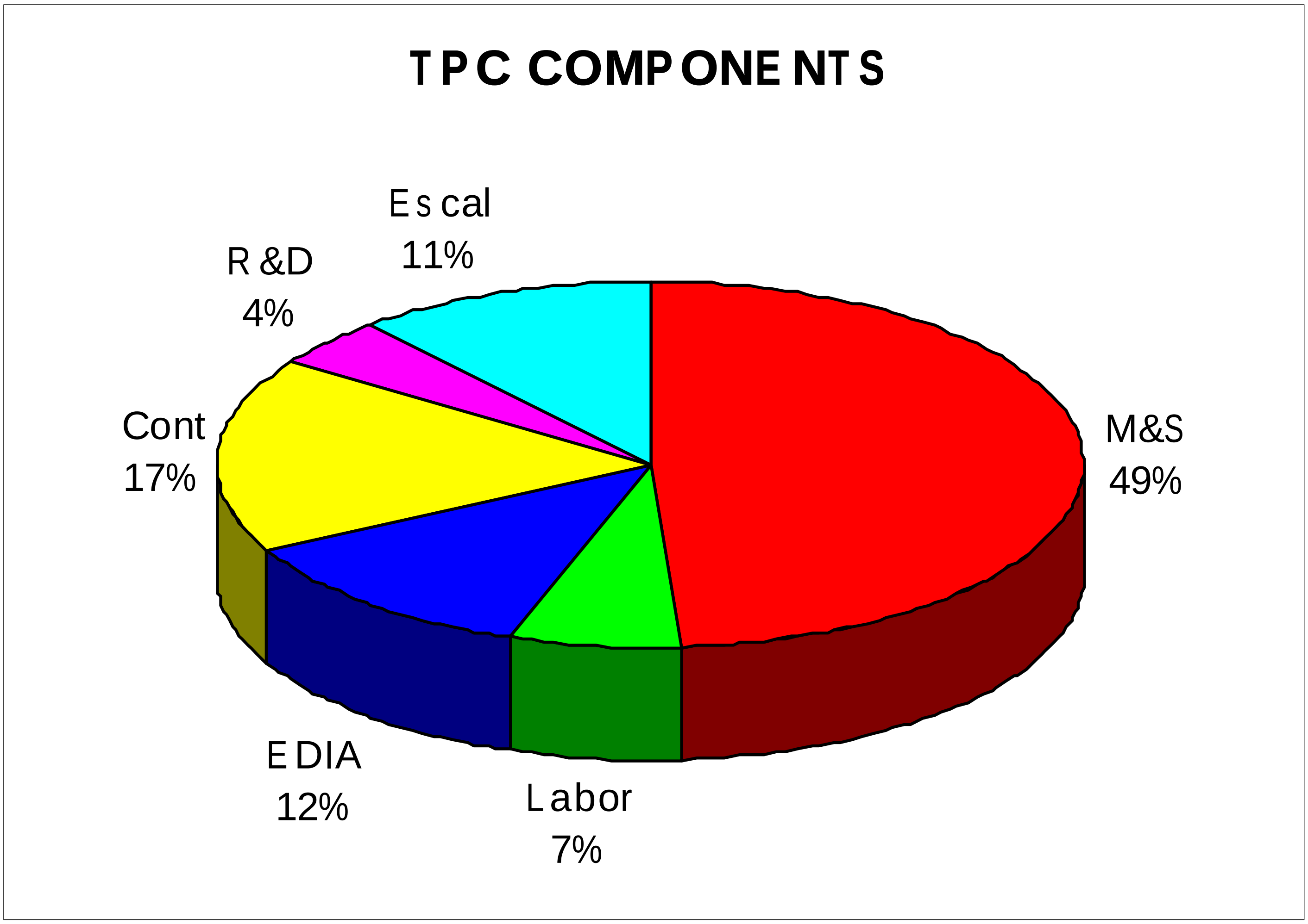
WBS Cost Drivers, L2

EMU + HCAL + CP + TRIDAS = 83% of the TEC



WBS Cost Drivers

The M&S Purchases dominate the WBS Cost Estimate, followed by Contingency, EDIA, and Escalation in that Order.



WBS Dictionary

The US CMS WBS Dictionary uses the “notes field” in MS Project so that it exists as an integral part of the overall cost and schedule file. The Basis of Estimate (BOE) exists in hard copy, maintained by each L2 manager.

<u>e.g.</u> WBS 7., Project Office:

The basis of estimate for the US CMS Project Office is derived from the costs of project management incurred in comparable projects. The NSF costs are specifically given by Steve Reucroft of NEU.

CDF: This is a 55 M$ project with substantial foreign contributions in addition. The PO has 4.8 FTE = 2 FTE PM, 0.8 FTE PE, 1 FTE FO and 1 FTE Sec.

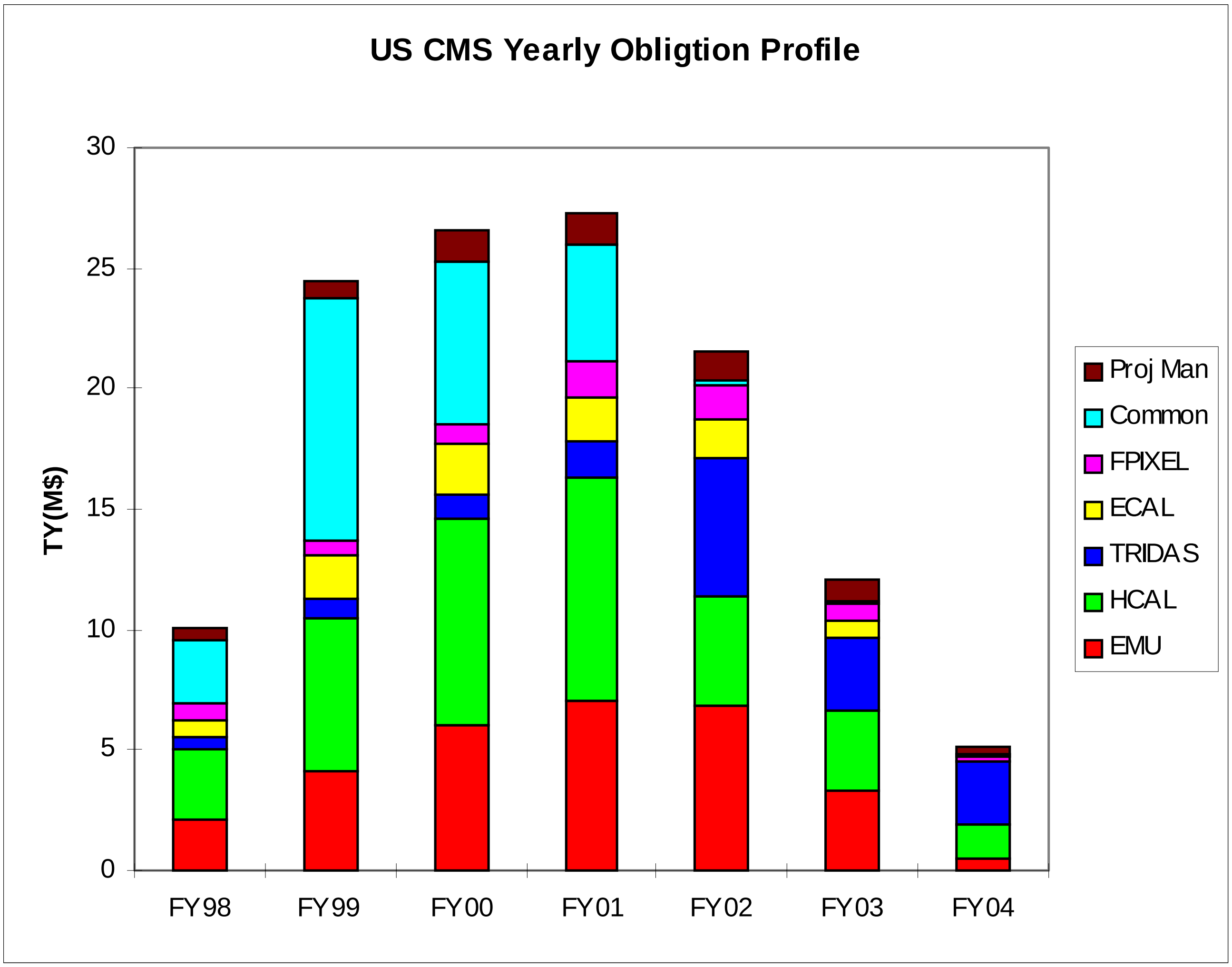
Babar: This is a 56 M$ project with substantial foreign contributions in addition. The PO has 3.5 FTE = 1 FTE PM, 1 FTE PE, 1 FTE FO

Phenix: This is a 43 M$ DOE project, but the total is about 100 M$ due to foreign contributions. The PO has 12 FTE = 1 FTE PM, 2 FTE DPM, 2 FTE PE, 2 FTE Secretary, 1 FTE Project Administrator, 1 FTE procurement specialist, 1 FTE facility manager, 1 FTE System Integration manager, 1 FTE RHIC liason. US CMS has PE supported by the L2 subsystems, the systems integration is vested with CERN, as is the LHC liason. Allowing for those differences, 8 FTE would be the adjusted estimate. However, PHENIX feels it was light on the FTE levels.

US CMS: This is a 168 M$ project. It is not responsible for installation and commissioning. It is not responsible for foreign contributions. There is no possibility of scope creep in the US CMS Project.
The PO has 7 FTE = 1 FTE PM, 1 FTE DPM, 1 FTE PE, 1 FTE FO 1 FTE software professional, 1 FTE Secretary, 1 FTE AA.
Consultants are budgetted for in engineering, ES&H and QA/QC.

US CMS Obligation Profile

The annual obligation profile is derived from the resource-loaded cost and schedule for each L2 subsystem of US CMS.



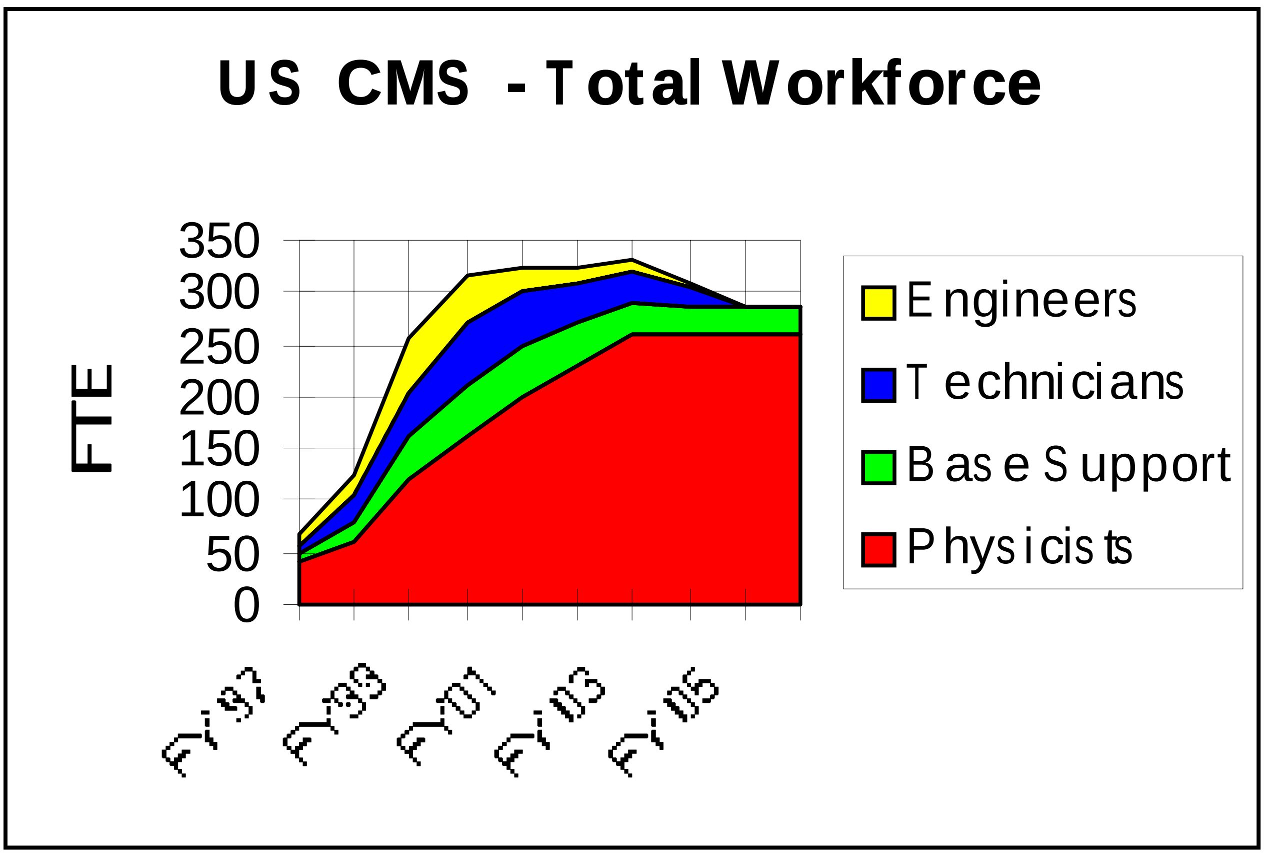
US CMS L1 Resource Pool

The L2 subsystem resources, along with the L1 “generic” resource costs, both labor and M&S, form the L1 resource pool.

	Resource Name	Initials	Group	Max. Units	Std. Rate	Ovt. Rate	Cost/Use
1	senior scientist	ph	Scientist	0	$0.00/d	$0.00/d	$0.00
2	post-doc	pd	Scientist	0	$0.00/d	$0.00/d	$0.00
3	computer professional - fermil	cp	Fermilab	0	$422.80/d	$0.00/d	$0.00
4	engineer - fermilab	en	Fermilab	0	$422.80/d	$0.00/d	$0.00
5	designer - fermilab	ds	Fermilab	0	$370.40/d	$0.00/d	$0.00
6	drafter - fermilab	df	Fermilab	0	$289.20/d	$0.00/d	$0.00
7	machinist - fermilab	ma	Fermilab	0	$447.20/d	$0.00/d	$0.00
8	technical specialist - fermilab	ts	Fermilab	0	$218.40/d	$0.00/d	$0.00
9	technician - fermilab	tc	Fermilab	0	$218.40/d	$0.00/d	$0.00
10	temp or student - fermilab	tm	Fermilab	0	$101.20/d	$0.00/d	$0.00
11	engineer - universiry	eu	University	0	$600.00/d	$0.00/d	$0.00
12	technician - university	tu	University	0	$240.00/d	$0.00/d	$0.00
13	machinist - university	mu	University	0	$280.00/d	$0.00/d	$0.00
14	temp or student- university	su	University	0	$80.00/d	$0.00/d	$0.00
15							
16	Technical Director	pm	PO Labor	1	$0.00/d	$0.00/d	$0.00
17	Construction PM	dpm	PO Labor	1	$1,000.00/d	$0.00/d	$0.00
18	Project Eng	pe	PO Labor	1	$800.00/d	$0.00/d	$0.00
19	Secretary	sec	PO Labor	1	$200.00/d	$0.00/d	$0.00
20	L2 Managers	l2	PO Labor	1	$0.00/d	$0.00/d	$0.00
21	ES&H Consulting	ESH	PO Labor	1	$400.00/d	$0.00/d	$0.00
22	QA/QC Consulting	qac	PO Labor	1	$400.00/d	$0.00/d	$0.00
23	Financial Officer	fin	PO Labor	1	$400.00/d	$0.00/d	$0.00
24	Software Professional	sp	PO Labor	1	$300.00/d	$0.00/d	$0.00
25	FNAL Eng Consultants	fe	PO Labor	1	$500.00/d	$0.00/d	$0.00
26	NEU Admin Asst	neuaa	PO Labor	1	$272.00/d	$0.00/d	$0.00

US CMS Manpower Profiles

The US CMS Project supports about 250 Ph.D. physicists. The project requires significant levels of engineering and technical manpower during the construction phase. During the phase where the experimental collaboration is taking data and in a phase of maintenance and operation, a constant level of base program support is assumed, based on the experience of LEP experiments.



L2 Subsystem Summaries

[presentation by L2 manager]

- **System overview**
- **L2 organization**
- **L2 milestones**
- **L2 status and progress, the percent complete**
- **WBS summary**
- **Schedule (MS Project) summary**
- **Manpower profile**
- **Obligation profile**
- **Concerns and how they are being addressed.**

Concerns and Actions Taken

- The contingency on Common Projects is difficult to assess. A meeting between the US CMS PMG and the CMS Magnet Technical Manager and Resource Manager was held at Fermilab to review the magnet Basis of Estimate (BOE).

- The contingency for the Project did not reflect past HEP experience. A series of meeting of the FNAL PMG reviewed each L2 subsystem in turn, examining the contingency levels uniformly across subsystems and in detail.

- The funding of the groups within US CMS was not sufficiently controlled. A Memorandum Purchase Order system was adopted as this provided more management control of the funding. A Statement of Work with each US CMS collaborating institution was written where deliverables and scope of work are specified to the lowest WBS level.

- The governance of US CMS did not distinguish between the experiment and the project management. Don Reeder heads the US CMS experiment as the Spokesperson. Dan Green and Ed Temple head the project management as the Technical Director and the Construction Project Manager respectively.